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How to develop an energy poverty assessment

Covenant of Mayors Guidebook | Complementary document 3

Joint Research Centre

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CONTENTS

Abstract

The Covenant of Mayors for Climate and Energy (CoM) is an ambitious initiative for local climate and energy actions. This guidebook provides local governments with methodological support for the development of sustainable energy and climate action plans (SECAPs) and focuses on the energy poverty assessment. It outlines a strategic approach for assessing energy poverty and setting targets. Additionally, it furnishes an array of indicators and resources to guide and empower municipalities in effectively assessing and then planning to alleviate energy poverty in their communities.

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1 Introduction

1.1 Objective of this guidebook

This guidebook aims to support municipalities that are signatories of the CoM EU in developing their energy poverty assessment and setting their energy poverty targets. It provides background information, insights and references to enable municipalities to make thoughtful choices tailored to their local conditions.

The guidance provided in this document is aligned with the energy poverty policy guidelines outlined in the Energy Efficiency Directive 2023/1791 (EED) (EU/2023/1791) and adheres to its principles. The document stands in between a theoretical guidance and the reporting guidelines, and it complements existing guidance and material developed so far, including the Energy Poverty Reporting guidelines produced by the Covenant of Mayors Office and the Energy Poverty Advisory Hub's (EPAH) energy poverty handbooks.

1.2 The GCoM energy poverty and energy access pillar

Energy access and energy poverty constitute the third pillar of the Global Covenant of Mayors for Climate and Energy (GCoM). At global level, the pillar is structured using three energy attributes as described in the GCoM Common Reporting Framework (CRF)[1].

The energy attributes are the following:

- Secure energy: energy is accessible and/or reliable, enabling access to economic, social and cultural engagement.
- Sustainable energy: energy is generated from renewable and non-pollutive resources—avoiding negative health, social and gender consequences.
- Affordable energy: energy is affordable and/or the building stock is energy efficient to maximise value of expenditure—enabling energy applications for economic, social and cultural opportunities.

Per each energy attribute, several indicators are made available to the municipalities to assess their local energy access and energy poverty conditions. Each GCoM region can select the most relevant energy attribute based on its local characteristics and energy needs, tailoring its energy assessment accordingly.

1.3 The energy poverty pillar in the European context

In the European region of the Covenant of Mayors, the focus is on the attribute of energy affordability, specifically addressed through the lens of energy poverty (see Figure 1).

[1] Global Covenant of Mayors Common Reporting Framework (CRF) available at: https://www.globalcovenantofmayors.org/our-initiatives/data4cities/common-global-reporting-framework/

Since this guidebook is tailored to the European context, the guidance hereby provided centres on the issue of energy poverty. Information on how to develop the energy assessment for the other two attributes - sustainability and security - is not covered in this document.

Looking specifically at the European context, the energy poverty reporting guidelines[2] from the Covenant of Mayors – Europe structure the energy assessment, and the related indicators, using six macro-areas that are related to energy poverty:

1. Climate.
2. Facilities and housing.
3. Mobility.
4. Socio-economic.
5. Policy and regulatory framework.
6. Participation and awareness raising.

The information, insights and references provided in this guidebook focus on the energy poverty topic and give information on how to carry out the energy poverty assessment considering the six macro-areas presented above.

Figure 1. Diagram of energy access and energy poverty pillar structure

Source: JRC elaboration

[2] Covenant-reporting-guidelines-energy poverty-2025

1.4 Structure of the guidebook

This guidebook is structured into four sections, each designed to offer targeted support and information for the development of the energy poverty assessment.

- Section 1 introduces the guidebook and contextualises the Energy Poverty and Energy Access pillar and specifies the approach used in the European context.
- Section 2 examines the state and dimensions of energy poverty in the EU, offering insight into legislative definitions and measures.
- Section 3 details the methodology for the energy poverty assessment providing a step-by-step approach for municipalities.
- Section 4 explores macro-areas and indicators to measure and monitor energy poverty.
- Section 5 provides for each indicator, practical guidance on processes, resources and examples to use while developing the energy poverty assessment.

Throughout the guidebook, each section builds upon the previous, ensuring a cohesive and comprehensive approach to addressing energy poverty through careful planning and targeted actions.

2 Energy poverty in the European Union

2.1 Current state and measures

Energy poverty is a diverse form of poverty driven by a combination of factors such as low-income, high-energy expenses, and poor energy efficiency in buildings having effects on the quality of life of people affected, on their health, education, and gender. Energy poverty may also lead to the use of unsecure and unclean sources of energy, which contributes to the environmental and climate causes.

In the EU context, the green transition is advancing rapidly and the contribution of renewable energy in the energy mix is increasing (17% in 2021), and 50% of energy produced in the EU in 2024 came from renewables (EC - DG COMM, 2024; EC - EUROSTAT, 2023). In addition, access to energy, both electricity and clean cooking, is universal across the EU. Therefore, the focus for European countries is on energy poverty.

As of 2023, energy poverty is a tangible phenomenon affecting millions of people across the EU. The scale of energy poverty can be assessed in several ways. According to Eurostat, over 47 million people in the EU (10.6 % of the population[3]) were unable to keep their home adequately warm in 2023. Moreover, in 2023 almost 7 % of the EU population had arrears on their utility bills[4], and in 2020 almost 15 % lived in dwellings with leak, damp or rot (last available year for data). In 2018, the poorest European households (i.e. the lowest 10 % income bracket) spent 8.3 % of their expenditure on energy (COM/2020/951).

Initiatives to tackle energy poverty are happening at multiple levels:

- At the EU level, the concept of energy poverty was introduced by Directive (2009/72/EC) and followed in 2016 by the launch of the Energy Poverty Observatory. Subsequent energy related legislative packages and recommendations along the years have evolved the definition of the topic and clarified the need for and importance of addressing the root causes behind energy poverty[5].
- At the national level, strategies and actions have been explored and undertaken by several Member States. Several EU countries have integrated targeted measures and are developing their own definitions, measurement and monitoring methods and solutions to energy poverty.
- At the local level, municipalities play a critical role in alleviating energy poverty, leveraging their deep understanding of the socio-economic conditions, specific needs, and challenges faced by affected households in their territories.

Within this context, in 2021 the EU launched the Energy Poverty Advisory Hub (EPAH) to create a space for collaboration and exchange between local and regional authorities to tackle energy poverty, while accelerating the just energy transition. The EPAH collaborates with the Covenant of Mayors Europe and develops methodologies and strategies tailored for the European context that are at the core of the EU Covenant's energy poverty pillar.

[3] https://ec.europa.eu/eurostat/databrowser/view/ILC_MDES01/default/table?lang=en

[4] https://ec.europa.eu/eurostat/databrowser/view/ILC_MDES07$DEFAULTVIEW/default/table?lang=en

[5] https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumers-and-prosumers/energy-poverty_en#eu-measures-to-tackle-energy-poverty

2.2 Energy poverty definition in the EU legislation

The concepts behind energy poverty have evolved since it was first proposed in the UK in the 1980s (Isherwood & Hancock, 1979). At the EU level, the recently released Energy Efficiency Directive 2023/1791 (EED) includes an EU level common definition of energy poverty linked to the ambition of a just and fair energy transition (C/2023/4080; EU/2023/1791; Lu & Ren, 2023; SWD/2003/647).

More specifically, Art 2, point 52 of the EED defines energy poverty as:

> *"energy poverty' means a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes".*

The definition reported above highlights some key elements characterising energy poverty and provides guidance on defining approaches for tackling it:

- Energy poverty is a common problem, but its articulation varies to reflect national and sub-national features and standards.
- The key actors are households; therefore, the necessary level of assessment and action is more granular and the approach transversal, not only focused on a direct place-based relation.
- Energy poverty has a multidimensional character manifested in its root causes and impacts.
- Everyone has the right to access essential affordable and easy to use services, tackling energy poverty is a crucial step in making this a reality.
- Addressing affordability is, in general, an essential step but it is not the sole.

In addition, the art 5 of the EED indicates that:

> *"Member States shall ensure that regional and local authorities establish specific energy efficiency measures in their long-term planning tools, such as decarbonisation or sustainable energy plans, after consulting relevant stakeholders, including energy agencies where appropriate, and the public, including, in particular, vulnerable groups which are at risk of being affected by energy poverty or are more susceptible to its effects."*

In this context, the EED clearly envisages the role of subnational levels of governance and stakeholders in alleviating energy poverty, leveraging their in-depth understanding of individuals' socio-economic conditions and the physical and spatial factors associated with land-use planning.
Finally, although not explicitly mentioned in the two articles of the EED, it is important to acknowledge the sectors both influencing and being influenced by energy poverty, such as public health, education, employment, infrastructure, and facilities.

3 The energy poverty assessment phases

3.1 Objective of an energy access and energy poverty assessment

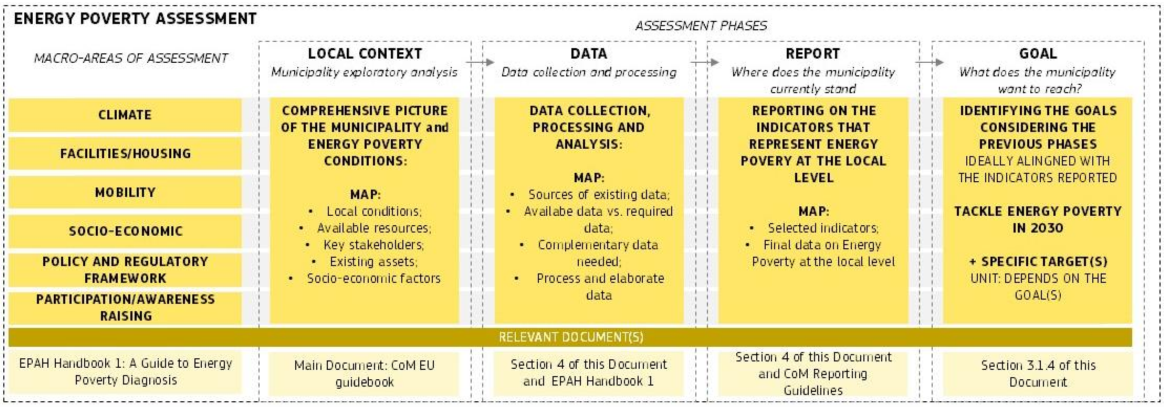
The objective of the energy assessment is to provide a comprehensive understanding of energy poverty within the local context, including its extent, underlying causes, and contributing factors, to inform effective action planning.
As energy poverty is a complex and multidimensional phenomenon driven by multiple transversal factors, the assessment is particularly important to understand how these elements interact together and impact the local context.
The multidimensional aspects of energy poverty are reflected in the macro-areas used in the European context. Ranging from local climate conditions to socio-economic circumstances and the existence of policy approaches, the macro-areas provide a framework to organise the assessment in a structured manner.
For each macro-area a set of indicators, selected through participatory process involving the Covenant community of municipalities and experts in the field, is made available to provide a picture of the status of energy poverty for municipalities.
The indicators aim at supporting municipalities to identify, measure and monitor as many aspects as possible to understand the energy poverty conditions across households and territories and to identify areas of intervention and prioritise them.
The grouping into macro-areas supports the analysis and provides a structured methodological framework. Overall, the concepts underlying energy poverty, the indicators, and the resulting policies are inherently interconnected and interdependent.

To carry out the energy assessment the signatory should follow the following phases:

1. Carry out a city exploratory analysis
2. Execute data collection and processing activities
3. Address the requirements of the energy assessment reporting against selected indicators
4. Use the information collected to set an energy poverty target

The following sections will elaborate the content of each phase and Figure 2 provides a simplified overview of the assessment process.

Figure 2. Energy assessment phases and references to guidebook documents



Source: JRC elaboration

At the end of the assessment, the signatories will have a detailed understanding of energy poverty in their local context, including insights from selected indicators across multiple macro-areas, enabling them to set informed goals, prioritise interventions, and design targeted policies and actions.

3.1.1 City exploratory analysis

The first phase, carrying out a city exploratory analysis, involves mapping the local conditions, available resources, key stakeholders, existing assets, and socio-economic factors to establish a comprehensive picture of the city's context and energy poverty landscape.

This phase is presented in detail in the document "How to develop a Sustainable Energy and Climate Action Plan (SECAP)" part of the CoM EU guidebook series as it is common across the mitigation and adaptation pillars.

3.1.2 Execute data collection and processing activities

Data collection, processing, and analysis are crucial steps in developing knowledge on and understanding energy poverty, ultimately informing targeted actions. However, this process often poses significant challenges for municipalities when preparing their SECAPs.
To ensure that data collection and availability do not become a barrier to local climate and energy action, the following operative steps can facilitate the process, along with relevant data sources and recommendations.

- After reviewing macro-areas and related indicators to identify those relevant to the local context, the first step is to conduct an inventory of existing data ("secondary data") across the municipality's departments, as energy poverty is influenced by multiple factors and relevant information may be found across sectors and areas. Secondary and existing data are those collected, recorded at an earlier time, often for a different purpose.
- Once these sources are mapped, the next step is cross-checking available data with the information required for suitable indicators in order to define the data that will be used for the energy poverty assessment. For instance, potentially useful data may be retrieved from the housing department to gather data on the building stock, or from the social department to acquire information on lower income population.
- In cases the secondary data available within the municipality are insufficient to complete the assessment, municipalities may supplement them by collaborating with specialised organisations and companies, such as housing associations and energy providers, as well as by engaging with research organizations and universities, and statistical offices.
- When new information is needed, primary data can be directly collected by the municipalities, also with the support of research organisations. This original data can be gathered through several methods like questionnaires, surveys, interviews, or observations. For example, specific questionnaires can be prepared to get information on transportation habits of individuals; or interviews can be conducted with specific population groups to understand the barriers they encounter in the payment of the bills. It is also possible to combine methods of data collection to produce complete datasets and complementing the strengths of each method used.
- Moreover, before populating the selected indicators, an intermediate step may be necessary to process and elaborate the data when these are not immediately suitable for the analysis. As an example, the indicators metrics are often expressed in percentage, and in terms of

population or households. Therefore, it is crucial to make the necessary conversions and calculations to ensure that data used for the indicators are consistent with the metrics.

The EPAH **"Handbook 1 - A Guide to Energy Poverty Diagnosis"**(EPAH, 2022) is a relevant source for further details and information.

Finally, two aspects are important when dealing with data for energy poverty:

- Local relevance: Efforts should be made to obtain data at the local level, as national information may not accurately represent local conditions, particularly for energy poverty, which is strictly correlated with the local context. However, if local data is unavailable, regional or national data can still be used with a certain approximation, if these are further elaborated to be adjusted to the local level. For example, through scaling, thereby adjusting national data based on relevant local-level variables, like population. National data can be also adapted to the local level by using the results of sample surveys conducted at the regional or local level.
- Data reliability: Ensure that the sources used are trustworthy, that collected data are accurate and that reflect the real conditions, by controlling and checking the results.

Potential sources of data include:

- Collected data by the relevant departments in the municipality
- Utility data
- Census data
- EU SILC (Statistics on Income and Living Conditions)
- Results from surveys, interviews, workshops
- Environmental/energy/climate Agencies
- Datasets and reports developed by research organisations and academic literature
- GIS databases (e.g., OpenStreetMap)
- Mobility reports from regional authorities

3.1.3 Address the requirements of the energy assessment reporting against selected indicators

While energy poverty is highly dependable on local perspectives and a product of a systemic inclusion of specific interactions across socioeconomic, environmental, political, cultural, and energy contexts, it is critical to ensure that based common principles can be applied.

The inclusion of a regional common definition, methodology and treatment of energy poverty will help to ensure recognition and respect for the needs and capacities of municipalities in an aggregated manner.

A single indicator cannot be enough to represent the systemic issue regarding energy poverty in a municipality, which is a multidimensional phenomenon as described in previous sections.

However, for the practical scope of this guidance, and based on a common standard approach, we recommend using at least one indicator which refers to:

- Percentage of persons/households spending up to XX % of their income on energy services.

This indicator measures the percentage of persons or households spending up to a specified percentage of their income on energy services, providing insight into the affordability of energy within the population. The specific percentage used as threshold can vary, and should be determined from the municipalities, according to the municipal conditions encountered. The indicator helps identify the financial burden of energy costs on households, assesses the risk of energy poverty, and informs targeted interventions to improve energy access and affordability for vulnerable groups.

While the one illustrated above is a key indicator, municipalities are encouraged to make use of as many indicators as possible to have a more nuanced understanding of the energy poverty multi-faceted problem.

The assessment phase should represent different aspects of the energy poverty problem, and it is possible that the signatory will need to respond to multiple indicators from the different macro-areas. A recommended approach from the EPAH handbook is to follow some guiding questions to try to identify "causes and effects" (social groups and geographical spread) of energy poverty in the municipality, such as:

- "What is the impact of poor energy efficiency and appliances?"
- "Are people aware of possible good practices?"
- "Who exactly are the people that live in this neighbourhood (people affected by unemployment, people with special health conditions etc.)?"

The identification of the vulnerable groups, for example, can make a real difference when capturing the specific situation of the municipality and be an important guidance to develop policies on energy poverty.

3.1.4 Set the energy poverty target

Building on the insights gained in previous phases—where the local energy context was analysed and initial data collected—the signatory may now set an energy poverty target.
Municipalities should establish both an overarching energy poverty goal and a specific energy poverty target:

- Energy poverty goal
  This involves committing to addressing energy poverty by a specific year. In the European context, the municipality will explicitly declare this commitment and select a target year.

- Specific energy poverty target
  Here, the municipality identifies and quantifies the desired improvement using a chosen energy poverty indicator from the assessment process. Box 1, Box 2 and Box 3 provide fictional examples of specific energy poverty target setting to understand how municipalities can choose from the whole range of indicators available to set their target.

During this target-setting process, it is also important to consider absolute numbers and demographic projections. Achieving a higher percentage of people living under better conditions is one target, at the same time ensuring that the total number of individuals or households experiencing energy poverty is also reduced makes the target more meaningful and reflective of true progress.

When setting the goal and the specific target, the municipality should always provide information on:

- Target year.

- Base year value.
- Reporting year value.
- Ambition.
- Units to quantify the baseline and target value.

Finally, for both the goal and the specific target, it is important that target setting, information obtained from the energy poverty assessment and action planning are aligned and coherent.

Box 1. "Aurora Springs" municipality - Fictional example of target setting focused on income

Context:

The municipality of "Aurora Springs" conducted its energy poverty assessment in 2024 (baseline year). The assessment showed that 88% of households spends up to 10% of their income on energy services, while 12% spends more than 10%. The municipality decides to set both the goal and a specific target for 2030 (target year), aligning with their overall energy and climate strategy.

Energy poverty goal:

By 2030, the municipality commits to explicitly address energy poverty, thereby integrating energy poverty considerations into all relevant municipal policies and plans.

Specific Energy Poverty Target:

Indicator: Percentage of households spending up to 10% of income on energy services.

Baseline (2024): 88% of households

Target (2030): 93% of households

Rationale:

The municipality aims to increase the share of households spending less than or equal to 10% of their income on energy services from 88% to 93%. This implies that fewer households will be spending more than 10%, thus reducing energy poverty.

Additionally, the municipality considers lowering the threshold from 10% to 9% in future years, if conditions allow. As they refine their targets, they will also consider absolute population numbers and demographic projections (e.g., expected population growth) to ensure that the total number of energy-poor households is reduced.

Units and reporting:

Units: Percentage of households (%)
Base year (2024): 88%
Reporting year(s): 2026, 2028, and 2030 to monitor progress

Ambition: A 5-percentage point improvement in affordability conditions, reflecting a substantial commitment to reducing energy poverty and improving living standards

Alignment with action planning:

In line with the 2030 target, all interventions will be timed accordingly and directed toward households most at risk, with regular monitoring to reassess vulnerability criteria and refine the approach as conditions evolve.
See Complementary document 4 for further details.

Box 2. “Riverdale Heights” Municipality – Fictional example of target setting focused on heating discomfort

Context:

The municipality of “Riverdale Heights” carried out its energy poverty assessment in 2024 (baseline year). The assessment indicated that 22% of households within the municipality experienced heating discomfort, defined as an inability to adequately heat the homes during cold months. The municipality decides to set both the goall and a specific target for 2030 (target year), aligning this effort with their overarching energy and climate strategy, focusing particularly on vulnerable populations such as low-income households, older people, and households with young children.

Energy poverty goal:

By 2030, Riverdale Heights commits to significantly reduce energy poverty among vulnerable population groups.

Specific Energy Poverty Target:

Indicator: Percentage of households within the municipality experiencing heating discomfort.
Baseline (2024): 22% of households
Target (2030): 12% of households

Rationale:

Riverdale Heights aims to decrease the share of households experiencing heating discomfort from 22% to 12%. This 10 percentage-point improvement specifically targets vulnerable households, including economically disadvantaged residents, older people, and families with small children.

The municipality also plans to continuously reassess and update vulnerability criteria and improve their identification methods, ensuring support reaches those most in need. Future adjustments might involve further lowering the target percentage, depending on interim progress and the evolution of socioeconomic conditions within the community.

Units and reporting:

Units: Percentage of households (%)
Base year (2024): 22%
Reporting year(s): 2026, 2028, and 2030 to monitor progress
Ambition: A substantial 10 percentage-point improvement in reducing heating discomfort, reflecting a strong municipal commitment to protecting vulnerable populations and enhancing overall living standards.

Alignment with action planning:

Aligned with the 2030 target, Riverdale Heights will implement targeted programmes such as home retrofits, heating system upgrades, financial assistance schemes, and tailored outreach campaigns specifically addressing vulnerable population groups. Progress will be regularly monitored, allowing refinement of actions and ensuring continuous support adaptation to evolving community needs. See Complementary document 4 for further details.

Box 3. “Brookfield Town” Municipality - Fictional example of target setting focused on arrears on energy bills

Context:

The municipality of "Brookfield Town" completed its energy poverty assessment in 2024 (baseline year). The assessment revealed that 15% of households had arrears on utility bills (electricity, gas, and district heating), indicating financial vulnerability related to essential energy services. The municipality has chosen to establish both the energy poverty goal and a specific target for 2030 (target year), incorporating them into its broader climate and energy strategy, with a clear emphasis on assisting vulnerable population groups such as low-income households, single-parent families, and older residents.

Energy poverty goal:

By 2030, Brookfield Town commits to substantially reducing energy poverty.

Specific Energy Poverty Target:

Indicator: Percentage of households in arrears on utility bills.
Baseline (2024): 15% of households
Target (2030): 7% of households

Rationale:

Brookfield Town targets a reduction of households in arrears on utility bills from 15% in 2024 to 7% by 2030, representing a significant reduction in financial distress related to energy services. By setting this target, the municipality explicitly prioritises alleviating the financial burden on vulnerable households, including those facing economic hardship, older residents on fixed incomes, and single-parent families.

Units and reporting:

Units: Percentage of households (%)
Base year (2024): 15%
Reporting year(s): 2026, 2028, and 2030 to monitor progress
Ambition: An 8 percentage-point decrease in households experiencing utility-bill arrears, demonstrating strong municipal commitment to reducing energy-related financial vulnerability among residents.

Alignment with action planning:

Aligned with the 2030 target, Brookfield Town will implement actions such as targeted financial assistance schemes, debt-management counselling, direct bill subsidies, and tailored communication and outreach campaigns. These interventions will focus explicitly on vulnerable households identified through continuous monitoring, allowing adjustments in municipal strategies and ensuring effective and sustained poverty alleviation.
See Complementary document 4 for further details.

3.1.5 Monitoring

The monitoring process for energy poverty assessment should be structured to ensure that the assessment and understanding of energy poverty conditions is both accurate and regularly updated:

- Indicator identification: During the assessment phase, key indicators specific to energy poverty are selected to establish a clear baseline for subsequent monitoring. These can be assessed periodically to keep track of their evolution.
- Progress tracking: These indicators can be used to systematically track progress, comparing current data with initial targets to measure the effectiveness of actions taken towards energy poverty alleviation.
- Regular verification: The energy poverty conditions within the community can be periodically reassessed to verify that the SECAP's objectives are being met and that the actions remain aligned with the identified needs.
- Responsive adjustments: Based on the monitoring outcomes, actions may be adjusted to better align with the original goals, ensuring that strategies are responsive to any changes in the local context.
- Continual relevance: The SECAP allows for flexibility to revisit and refine the assessment phase, incorporating new indicators as necessary to adapt to evolving energy poverty dynamics and maintain the relevance of the plan.

More information on the monitoring process is provided in the Main Document: "How to develop a Sustainable Energy and Climate Action Plan (SECAP)"(Davide et al., 2025) and Complementary document 4 on "How to develop mitigation, adaptation and energy poverty actions" (Hernández Moral et al., 2025).

4 Energy poverty macro-areas and indicators

This section provides a framework to understand how macro-areas considered in the energy poverty assessment relate to energy poverty in different ways and how they each, with their associated indicators, contribute to build a more complete understanding of the local context.

For example, unlike direct measures of energy poverty, some indicators to be used in the energy poverty assessment highlight conditions or risks associated with it, such as factors that limit access to energy services or compromise households' ability to meet their energy needs for well-being. Additionally, not all indicators are directly linked to actions within a local authority's control; for instance, climate-related indicators fall outside municipal influence.

This framework emphasises the importance of interpreting such "indicative" risk indicators during the energy poverty assessment and using them strategically to inform goals and design actionable interventions.

The information provided in this section goes beyond existing reporting guidelines and handbooks by providing a deeper, practical exploration of the rationale behind each macro-area and related indicators. This enables municipalities to approach the energy assessment for each macro-area with greater clarity, insight and self-awareness.

4.1 Climate macro-area

- Why is the climate macro-area relevant to energy poverty?

Climate conditions are one of the factors influencing energy consumption patterns of a household. Outdoor temperature influences indoor thermal comfortable conditions. In extreme climate conditions, inside comfort can be compromised which may lead to the use of systems and appliances, such as heaters, fans and air conditioners. Some of these types of equipment and appliances may require a significant level of energy consumption, especially when compared to other home appliances.

Although thermal discomfort is perceived differently from person to person, there are some extreme conditions where climate stress can compromise physical and psychological integrity. People should be able to attend to their energy needs to guarantee indoor thermal comfort and reduce their vulnerabilities to heat or cooling strains.

Therefore, to reinsure indoor comfort in some climate conditions an increase in energy consumption is expected. The higher the energy consumption, the more households are exposure to higher energy expenditures, which can lead to budgetary instability and increase the risk of being in an energy poverty condition.

- Which indicators in the climate macro-area are to be considered for the energy assessment?
    - Frequency of heat waves.
    - Frequency of cold waves.
    - Number of heating degree days per year.
    - Number of cooling degree days per year.

Chapter 5.1 Data collection pathways for climate provides detailed information on these indicators.

- How can indicators in the climate macro-area help complete the energy poverty assessment?

Monitoring climate conditions can enable the municipality to understand weather and temperature patterns revealing the regions that are most vulnerable to climate-induced energy poverty. Climate indicators alone do not indicate energy poverty conditions, but they are a relevant measure to understand vulnerable energy conditions that may occur from extreme temperatures.

The frequency of extreme climate events, such as frequency of cold waves and frequency of hot waves, can be used as an indicator of climate and energy related issues. These indicators mark the number of heat/cold waves in a given time (which can be a month or a year). With that indicator, it is possible to understand the level of exposure of the local population to extreme climate conditions, which can be linked with an increased need for thermal comfort-related energy services.

Another type of indicator is the Heating/Cooling degree-days. Those indicate the number of days in which the outside temperature exceeds, or is below, a certain comfort temperature. These indicators are commonly linked with the energy needs of a household. The indicator assesses the level of variation on the use for heating/cooling energy services based on the outside temperature and the gap of this temperature from a decided comfortable temperature level.

4.2 Facilities and housing macro-area

- Why the facilities and housing macro-area is relevant to energy poverty?

This macro-area relates to the physical/technical conditions of a household, or its surroundings, that may affect the access to quality energy services. This includes indicators on the direct access of energy at a household, or it can be related to the housing quality levels.

Housing quality significantly influences energy poverty levels. Poor insulation and inefficient facilities lead to higher energy consumption and discomfort, key aspects of energy poverty. These indicators evaluate household and dwellings' energy performance, identifying areas where improvements could alleviate energy poverty.

- Which indicators in the facilities and housing macro-area are to be considered for the energy assessment?
    - F+G+H band (EPC) dwelling / total number of dwellings
    - Energy consumption (electricity + heating) per capita / national energy consumption (electricity + heating) per capita
    - Share of buildings renovated per year
    - Share of households / population with presence of leak, damp, rot in their dwelling / total households or population

- Percentage of households / persons within the municipality experiencing heating discomfort
- Percentage of households / persons within the municipality experiencing cooling discomfort
- Households / persons connected to the electricity grid / total households or persons
- Households / persons connected to the gas grid / total households or persons

Chapter 5.2 Data collection pathways for facilities and housing indicators provides detailed information on these indicators.

- How can indicators in the facilities and housing macro-area help complete the energy poverty assessment?

Indicators on facilities and housing assess the conditions of a household that may affect energy consumption and put the place at risk of energy poverty. For the purpose of the guidebook and to help municipalities understand how facilities and housing characteristics are linked with energy poverty, the different indicators within this macro-area are categorised and illustrated in sub-groups as follow:

- Energy efficiency: Energy efficiency indicates the amount of energy needed to reach a certain level of energy service at home. Inefficient houses will require more energy to reach thermal comfort than efficient houses. The high level of energy use leads to a high level of energy expenditure, which can compromise the energy affordability of a household, and put this home at risk of energy poverty. Identifying inefficient structures can help on improving the quality of local buildings structure.

  Indicators that are part of this sub-group are: i*) F+G + H band (EPC) dwelling / total number of dwellings, ii) Energy consumption (electricity + heating) per capita / national energy consumption (electricity + heating) per capita, iii) Share of buildings renovated per year.*

- Housing conditions (comfort and structure): This indicator is related with energy efficiency, as, housing conditions, access to some modern electrical appliances and internal infrastructure can guarantee that a house is able to use energy services efficiently when needed. Some Indicators in this group relate to the overall structure, as the external conditions of walls and windows, the presence of leaking or damp can indicate structural issues that would lead to inefficiencies for maintaining the internal thermal comfort. Other types of indicators can be related to the presence of specific appliances or centralised heating/cooling systems. These indicate the availability of energy services, like heating at home. Also, indicators on thermal comfort at home can be used more directly, representing an overall condition that is reached by those who live in the home..

  Indicators part of this sub-group are: *i) Share of households / population with presence of leak, damp, rot in their dwelling / total households or population, ii) Percentage of households / persons within the municipality experiencing heating discomfort, iii) Percentage of households / persons within the municipality experiencing cooling discomfort.*

- Energy consumption: The level of energy consumption of a house can indicate a higher/lower level of use, when compared with the average use of the surroundings. The higher level of energy can indicate inefficient energy use, leading to higher energy costs. The lower level of energy use can indicate a gap in the use of energy in that location, or that the household is not able to use all the energy services required to have a decent living.

  Indicators part of this sub-group are: *Energy consumption (electricity + heating) per capita / national energy consumption (electricity + heating) per capita*.

- Access to energy infrastructure: The access to energy infrastructure is a key measure of energy poverty and can directly show that a house lacks modern energy. These indicators measure whether a household has access to modern energy services and if this access is of quality. This group of indicators includes the percentage of households / persons with access to clean cooking fuels and technologies and households connected to the electricity/gas grids.

  Indicators part of this sub-group are: *i) Households / persons connected to the electricity grid / total households or persons, ii) Households / persons connected to the gas grid / total households or persons.*

4.3 Mobility macro-area

- Why is the mobility macro-area relevant to energy poverty?

Transportation needs and practices can contribute to aggravate the condition of energy poverty. For instance, limited mobility options and poor accessibility may lead households to rely on expensive private mobility options, increasing their expenditure and vulnerability to volatile fuel prices.

Households may also face trade-offs between domestic energy needs and transportation costs. For example, a family in rural areas with limited public transportation may have no choice but to use a private vehicle (forced vehicle ownership), incurring high fuel and maintenance costs that lead to adopt energy limiting behaviours to afford energy bills (Martiskainen et al., 2021).

The intersection between energy poverty and “transport poverty” (EC - DG EMPL et al., 2024), generally referring to a lack of accessible and affordable transport services, has gained increasing attention as they both share similar causes and impacts. This overlap is known as double-energy vulnerability. Some of the factors that make a household vulnerable to both energy and transport poverty include having a low income, being a woman, belonging to an ethnic minority, having a disability, being unemployed, or being a single parent[6] (Martiskainen et al., 2021).

Being in the condition of energy and/or transport poverty implies worse standards of living, a limited participation in the society, and negative impacts on wellbeing (Furszyfer Del Rio et al., 2023; Lowans et al., 2023; Robinson & Mattioli, 2020; Simcock et al., 2021). Mobility and access to services are linked to energy poverty through transport costs. Limited public transport and distant essential services increase household expenses, contributing to overall energy poverty.

[6] Understanding transport poverty, European Union 2022. https://www.europarl.europa.eu/RegData/etudes/ATAG/2022/738181/EPRS_ATA(2022)738181_EN.pdf

- Which indicators in the mobility macro-area are to be considered for the energy assessment?

    - Population / households not having access to essential services within 1 hour by walking, cycling or public transport / total population
    - People / households living more than one 1 km from nearest public transport station / number of population

  Chapter 5.3 Data collection pathways for mobility indicators provides detailed information on these indicators.

- How can indicators in the mobility macro-area help complete the energy poverty assessment?

The indicators under this macro-area measure accessibility to services through public transport and the availability of services and public transport infrastructures, which are drivers for energy poverty, as mentioned before. Being not well connected and/or far from essential services is indicative of a condition where to fully participate in the society, people have to allocate a portion of their budget to transportation costs, which may leave them struggling to pay their energy bills.
Therefore, these indicators highlight areas where high transportation costs compound energy poverty issues, as well as groups in need and areas of interventions.

4.4 Socio-economic macro-area

- Why is the socio-economic macro-area relevant to energy poverty?

Often, energy poverty condition is associated with other forms of social/economic vulnerability. This macro-area intends to identify economic aspects and/or social characteristics of household members that may influence energy poverty. If a household is in a vulnerable situation, it is more likely that it lacks energy services and energy comfort.

Economic vulnerability can be understood as a condition that can compromise the capacity of afford for energy and guarantee all energy needs of a person/home. This situation can be related to income constraints and/or high levels of energy expenditures. High share of income spent on energy, utility bill arrears, and the inability to maintain adequate temperatures are direct manifestations of energy poverty.

On the other hand, social vulnerability relates with the increased probability that some social groups suffer from energy poverty, not being able to reach all their energy needs or by being at higher risk when confronted with energy constraints. Being at risk of poverty, or having some vulnerable groups at home, such as older people or children, can increase the probability and severity of the energy poverty condition.

Understanding socio-economic factors is crucial to identify specific determinants of vulnerable energy poverty and how to act to reduce these vulnerabilities.

- Which indicators in the socio-economic macro-area are to be considered for the energy assessment?

    - Percentage of persons / households spending up to X% of their income on energy services
    - Vulnerable households or persons / total households or persons
    - Arrears on utility bills / total population or households
    - Inability to keep home adequately warm
    - Inability to keep home adequately cool
    - High share of energy expenditure in income (2M)

    Chapter 5.4 Data collection pathways for socio-economic indicators provides detailed information on these indicators.

- How can indicators in the socio-economic macro-area help complete the energy poverty assessment?

Socio-economic macro-area indicators assess the economic and social vulnerability of a household. These indicators represent a measure to understand which type of population is at risk of being in an energy poverty condition due to an economic constraint or because of a social condition. For the purpose of the guidebook and to help municipalities understand how socio-economic characteristics are linked to energy poverty, the different kinds of indicators within this macro-area are categorised and illustrated in sub-groups as follow:

- Energy affordability: These indicators include economic aspects that are directly related to energy expenditures. It includes indicators related with the ratio of energy expenditures in the total income or share of population with arrears on the energy utility bills. It also includes indicators related to the costs of energy, like the prices of gas or electricity.
  Indicators part of this sub-group are: *i) Arrears on utility bills / total population or households, ii) High share of energy expenditure in income (2M).*

- Economic vulnerability: These indicators relate to the economic/income conditions that denote that a household is at higher risk of energy poverty. These groups of indicators are not directly energy-related, covering people having difficulty in paying for energy at their homes based on the overall economic situation of a household. This includes people that are at risk of poverty, those that receive some social benefits or are unemployed.
  Indicators part of this sub-group are: *Percentage of persons / households spending up to X% of their income on energy services.*

- Social vulnerability: Indicators on social vulnerability identify population groups that, for their social condition, are at more risk of energy poverty, or those who are more vulnerable under this condition. Older people, families with children, people suffering from respiratory or circulatory problems are most likely suffering from energy poverty conditions. Also, the level of education is often associated with some social vulnerabilities, that can increase the probability of suffering from energy poverty too.
  Indicators part of this sub-group are: *Vulnerable households or persons / total households or persons.*

- Adequate thermal comfort: Those indicators directly measure the ability to maintain the important energy service of thermal comfort. It can be considered a direct measure of energy poverty as it indicates if an individual is able or not to maintain the household in a thermal comfort condition. If a household is inadequately warm or inadequately cool it is considered being in an energy poverty situation. These indicators are person-sensitive. Indicators part of this sub-group are: *i) Inability to keep home adequately warm, ii) Inability to keep home adequately cool.*

4.5 Policy and regulatory framework macro-area

- Why the policy and regulation macro-area is relevant to energy poverty

This macro – area refers to multiple policies and regulation approaches that separately or jointly can establish processes to alleviate energy poverty, by acting on multiple levers and from multiple sides. For instances, incentives may support investments (i.e., in energy efficiency, or renewables) after which the condition of energy poor is less pronounced. Subsidies can act to support households in energy poverty to overcome specific moments or conditions. Regulations establish limits and specific rules safeguarding the most vulnerable.

- Which indicators in the policy and regulation macro-area are to be considered for the energy assessment?

    - Existence of energy poverty strategy
    - Existence of rent regulation

  Chapter 5.5 Data collection pathways for policy and regulatory indicators provides detailed information on these indicators.

- How can indicators in the policy and regulation macro-area can help complete the energy poverty assessment

Policy and regulatory frameworks play a vital role in combating energy poverty. Strategies like rent regulations, that may set a cap in the renting prices or may disconnect the price from inflations; or energy efficiency incentives, enabling owners or tenants to meet the upfront cost of energy renovations, can mitigate energy poverty. These indicators reveal the existence of supportive policies, showing where systematic approaches to address energy poverty are in place or needed.

4.6 Participation and awareness-raising macro-area

- Why the participation and awareness-raising macro-area is relevant to energy poverty?

The Participation/awareness-raising macro-area focuses on initiatives informing the public about energy poverty. Given the high context specificity of energy poverty, the engagement of residents is crucial to better understand the local conditions prior to setting strategies and actions. In parallel, the level of energy literacy of individuals is also determinant for recognising bad practices in places, some of which can be addressed directly, by turning bad practices into positive behaviours. Finally, informing and disseminating allow raising awareness and ensuring that the changes and impacts are scalable and long lasting.

- Which indicators in the participation and awareness-raising macro-area are to be considered for the energy assessment?

    - Awareness-raising campaigns targeting vulnerable households
    - Engagement and cooperation with local stakeholders on energy poverty

    Chapter 5.6 Data collection pathways for participation and awareness raising indicators provides detailed information on these indicators.

- How indicators in the participation and awareness raising macro-area can help complete the energy poverty assessment?

These indicators assess campaigns targeting vulnerable households and local stakeholder engagement. This approach aims to empower communities, promote energy-saving practices, and ensure solutions addressing specific needs of energy-poor populations and it contributes to developing comprehensive strategies against energy poverty.

5 Indicators and data collection pathways

A key element to complete a sound energy poverty assessment consists in collecting the data necessary to report against the assessment indicators. However, data availability and data quality are often a critical challenge for municipalities. This is especially relevant for a complex and relatively new field such as energy poverty.

This section takes a structured view of each energy poverty indicator and provides a clear step by step process to follow in the data collection process by indicating:

- Steps to be followed in the data collection process.
- Examples of data sources to be considered.
- Stakeholders to engage with.

While each indicator provides specific and tailored information, the guidance can be adapted and used also as inspiration for other indicators.

Practical guidance is also provided to guide signatories in dealing with situations when no data is readily available. In this case, two approaches on how to proceed are provided:

- A high-end option, named Option 1, that aims to collect high-quality and high-resolution data, but requires significant resources, either in terms of time or financial, to complete the process
- A low-end option, named Option 2, which intends to collect low resolution data, often using proxies or data from a regional or national scale, to have an approximate description of the local context.

Both options have pros and cons and are hereby presented to give inspiration to municipalities in how to close energy poverty related data gaps and define their data collection pathways.

This section of the guidebook complements existing reporting guidelines and handbooks by providing a detailed review of the steps to be followed in the data collection process per each indicator and what to do to address the lack of data. In some cases, real examples are also included showing how peers or other actors are dealing with similar data challenges issues. These references can be used by local authorities in defining their data collection strategies to complete successfully the energy poverty assessment part of their SECAP.

5.1 Data collection pathways for climate indicators

5.1.1 Frequency of heat waves and cold waves

Data collection steps

The following steps and resources could be considered by the municipality when reporting against climate indicators:

- Process:
  - Collect historical weather data for the municipality from local meteorological services.
  - Analyse the data to determine the frequency of days exceeding heat and cold wave thresholds.
  - Validate the findings through consultation with local meteorological experts or agencies.

- Sources of data:
  - National or regional meteorological services (e.g., European Climate Data Centre).
  - Copernicus – European State of the Climate.[7]
  - Local weather stations or municipal or regional climate reports.
  - European Environment Agency (EEA) climate data.

- Stakeholders to engage with:
  - Meteorological institutes or local weather services.
  - Academic researchers specializing in climate studies.
  - Local environmental NGOs.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Consider using remote sensing data and satellite imagery from open-source climate data platforms (e.g., Copernicus) to approximate temperature trends and extreme weather events.

  For example, the European Drought Observatory (EDO) provides the Heat and Cold Wave Index (HCWI) for detecting periods of prolonged extreme temperature anomalies that could be used by the local authority. This index is:
  - computed for each location on a 1/4 decimal degree grid.
  - detects events with daily minimum and maximum temperatures above the 90th percentile (for heat waves) or below the 10th percentile (for cold waves) for at least three consecutive days.
  - uses a 30-year climatological baseline period (1981-2010) and covers a geographic area encompassing most of Europe.

How fellow European cities are using climate satellite data to create impact on the ground:
The city of Vienna (Austria) has utilised Copernicus data and services to develop a detailed urban heat vulnerability map. This high-resolution map helps city planners identify areas that are most susceptible to extreme heat events and is used in the following way:

[7] https://climate.copernicus.eu/ESOTC

- Urban heat vulnerability mapping: the city partnered with ECOTEN, a Prague-based company, to create a comprehensive urban heat vulnerability index (UHVI) map. This map uses Copernicus data to provide high-resolution information about heat vulnerability across the city's electoral districts.
- Identifying hot spots: the UHVI map revealed several heavily populated areas with a vulnerability index value of 0.9 on a scale where 1.0 implies high vulnerability to extreme heat events. The map also identified 10 specific 'hot spots', including areas with little to no green space or high concentrations of vulnerable populations like young children and older adults.
- Targeted Interventions: using this map, Vienna's city planners can now adapt their urban planning strategies to address the realities of a warmer climate. For example, the map has informed the city's "Cool Street" project, which aims to reduce heat at the street level through measures such as planting more trees and reducing traffic.

- Option 2: Consider using Copernicus data and publicly available dataset

  For example, municipalities can access data from Copernicus Climate Change services[8] and related key products and services, i.e. Climate Atlas and Climate Pulse, to collect data on heatwaves and the temperature trends of specific locations.

5.1.2 Number of heating degree days and number of cooling degree days per year

Data collection steps

The following steps and resources could be considered by the municipality when reporting against climate indicators:

- Process:
  - Obtain temperature records for the municipality from a reliable weather data source and identify baseline temperatures.
  - Calculate heating degree days (HDD) and cooling degree days (CDD) based on the deviation from baseline temperatures.
  - Cross-check with historical data to ensure consistency and accuracy.

- Sources of data:
  - Eurostat's climate statistics.
  - European Climate Assessment & Dataset (ECA&D).
  - Local meteorological services.

- Stakeholders to engage with:
  - Municipal environmental departments.
  - Local climate scientists and academic institutions.
  - National weather agencies.

[8] https://climate.copernicus.eu/; https://atlas.climate.copernicus.eu/atlas; https://pulse.climate.copernicus.eu/

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Collect daily temperature data through local temperature sensors or citizen science programmes, then calculate HDD and CDD.

  For example, the Copernicus Climate Change Service (C3S) provides a comprehensive and high-resolution dataset for HDD and CDD calculations across the European Union. This service, operated by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Commission, offers a sophisticated approach to temperature data collection and analysis. This solution could enable municipalities to access highly accurate and standardised HDD and CDD data without the need to implement their own extensive sensor networks. [9] [10]
    - Key features of this solution include:
      - Resolution data: C3S provides gridded temperature data at a 25 km resolution for the entire Europe.
      - Integration of multiple data sources: the service combines data from approximately 3 000 weather stations across Europe, satellite observations, and advanced climate models to provide comprehensive coverage.
      - Long-term historical data: the service offers temperature data dating back to 1979, enabling long-term trend analysis of HDD and CDD.
      - Standardised methodology: C3S uses a consistent methodology across all EU member states, ensuring comparability of data between different regions and countries.
      - Accessibility: the data is freely available to all EU municipalities.

How European cities are using sensors and data to create impact on the ground:

The "Leuven.cool" network in Leuven (Belgium) demonstrates an innovative approach to collecting high-resolution temperature data that could then be used for calculating HDD and CDD. This citizen science project involves around 100 low-cost weather stations distributed across the city of Leuven and its surroundings. The network uses wireless digital consumer weather stations to measure various meteorological variables, including temperature.[11] [12] [13]

By implementing a similar citizen science network, municipalities could obtain high-resolution temperature data specific to their local context. It is to be noted that adequate data quality control methods should always be in place to ensure trustworthiness of data collected.

Key aspects of the approach used by the city of Leuven include:

- Dense network: 106 weather stations are distributed across an urban gradient, from green private gardens to public grey locations, following a sampling design based on local climate zones (LCZ).
- Data quality control: the project employs a statistically-based quality control method to ensure the accuracy of the crowdsourced air temperature data.

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[9] https://climate.copernicus.eu/

[10] https://atlas.climate.copernicus.eu/atlas

[11] https://www.beesmart.city/en/smart-city-blog/leuven-smart-city-strategy-networked-smart-climate-neutral

[12] https://essd.copernicus.org/articles/14/4681/2022/

[13] https://www.kuleuven.be/plant-institute/research/urban-ecosystems/projects/leuven-cool

- High temporal resolution: temperature measurements are taken every 16 seconds, allowing for detailed analysis of temperature variations throughout the day.
- Urban climate understanding: the network provides insights into intra-urban weather patterns, which is crucial for calculating accurate HDD and CDD in urban environments
- Cost-efficiency: the use of low-cost weather stations makes it feasible to deploy a dense network of sensors across the city.

- Option 2: Use historical temperature data from the nearest weather station for estimation.

  For example, municipalities can use regional HDD and CDD data aggregated at different administrative levels (like NUTS-2 and NUTS-3) calculated using meteorological data and standardised methods. These resources can be accessed for example through the JRC Agri4Cast Portal, which includes monthly records of HDD and CDD across the whole European Union over multiple years [14] [15]. However, this approach would not be highly reliable but can be used for forming an initial understanding of the situation to be finetuned and confirmed once data at the local level becomes available.

[14] https://agri4cast.jrc.ec.europa.eu/DataPortal/Index.aspx

[15] https://ec.europa.eu/eurostat/cache/metadata/en/nrg_chdd_esms.htm

5.2 Data collection pathways for facilities and housing indicators

5.2.1 F+G+H band (EPC) dwelling / total number of dwellings

Data collection steps

The following steps and resources could be considered by the municipality when reporting against facilities and housing indicators:

- Process:
  - Access the municipal database on building energy performance certificates (EPCs).
  - Classify dwellings according to EPC bands and calculate the share of F, G, and H band dwellings.
  - Confirm data accuracy through a sample survey or energy audits.

- Sources of data:
  - Municipal or regional EPC registers.
  - National energy performance certificate databases.
  - Real estate and housing associations.

- Stakeholders to engage with:
  - Local housing authorities.
  - Energy auditors and building certification bodies.
  - Property management companies.

What to do when data is not readily available

The following options could be considered as an example by the local authority:

- Option 1: Conduct building surveys or energy audits with universities or NGOs specializing in energy efficiency.

  For example, the Digital building stock model (DBSM), backed by the European Commission's Joint Research Centre, leverages Earth observation, various heterogeneous data sources, and machine learning models to develop an open digital map of the EU's building stock, incorporating a growing array of energy-related features at the building level. This detailed mapping aims to empower decision-makers to make more informed choices, moving beyond simplistic statistics, particularly in relation to the building renovation wave and the recovery and resilience plans of member states[16].

How European cities are using digitalization to map and track the building stock energy efficiency status?
Amsterdam's Energy Atlas project enhances energy management by utilizing urban data to promote renewable energy awareness among citizens and businesses. This interactive platform enables public and private stakeholders to share anonymised energy, water, and sewerage usage data at a building-block level throughout the city.

[16] https://data.jrc.ec.europa.eu/collection/id-00382

From January 2012 to August 2015, the project was funded by the Transform project, with the city administration leading data integration and partner engagement. Participating utilities and housing corporations contributed data anonymously, overcoming technical and legal challenges. The Energy Atlas now provides real-time energy consumption data, continuing without European funding[17] [18].

- Option 2: Use national EPC statistics and apply them proportionally to the local housing stock, based on known building characteristics, such as the period of construction. However, this approach would not be highly reliable but can be used for forming an initial understanding of the situation to be finetuned and confirmed once data at the local level becomes available.

5.2.2 Energy consumption per capita (electricity + heating) / national energy consumption per capita

Data collection steps

The following steps and resources could be considered by the municipality when reporting against facilities and housing indicators:

- Process:
    - Collect data on electricity and heating consumption from local utility companies.
    - Aggregate consumption data and normalise by the population to determine per capita values.
    - Compare municipal values with national data available from energy statistical offices.

- Sources of data:
    - Municipal energy departments.
    - Local utility companies.
    - Eurostat energy statistics.

- Stakeholders to engage with:
    - Energy providers and utility companies.
    - Local government departments for energy.
    - Energy policy researchers.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Collect data using smart meters and IoT devices across a sample of households and extrapolate the results.

How European cities are collecting and making available data on energy consumption?

- The city of Helsinki (Finland) has developed an energy and climate Atlas that contains information about renewable energy and possibilities for energy renovations throughout the Helsinki region, including also information on energy consumption. The Atlas is part

[17] https://amsterdamsmartcity.com/updates/project/energy-atlas

[18] Smart City Data Governance "BOX 1.4" - https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/10/smart-city-data-governance_fc19e878/e57ce301-en.pdf

of a larger project developed by the municipality aimed at creating a digital twin of the city.
    - The Atlas has been compiled from the register data of buildings, and it contains a wide range of information about buildings' heating sources, materials, refurbishment history and conservation status. It contains four sections: i) solar energy potential, ii) heating demand prediction, iii) geo-energy potential, iv) energy data of buildings.

    - The Atlas includes consumption data on city-owned Helsinki Housing Company (Heka) housing buildings and calculations of heat, user electricity and property electricity consumption for all Helsinki buildings based on the building's age and size[19].

- Option 2: Estimate energy consumption using average figures from regional or national data, adjusted (through methods such as normalisation) for the municipal population. However, since these estimates are derived and elaborated, and not directly collected from local data sources, some discrepancies are possible. In such cases, when information is available for a small sample of households/residents, a comparison between data elaborated from the national/regional average and local data can help assess the extent of the divergence.

  For example, when local data is not directly available, it is possible to use methodologies that elaborate national data to approximate information at municipal level. Researchers from the University of Seville have proposed a methodology that allows to estimate the electricity and heating needs at municipal and per capita level for Spanish cities with population above 50 000 inhabitants. The methodology makes use of a categorization based on climatic zones and the location of municipalities to estimate thermal and electricity needs at municipal, household and per capita level (Zarco-Soto et al., 2020).

5.2.3 Share of buildings renovated per year

Data collection steps

Renovating public, private, residential, and non-residential buildings, particularly when combined with energy efficiency and renewable energy interventions, can significantly contribute alleviating energy poverty. Understanding the municipality's renovation rate would offer valuable insights into renovation frequency, equipment lifespans, and energy efficiency of each building. Moreover, the renovation rate could also help identify areas in need of renovation and highlight where efforts should be intensified or adjusted.

The following steps and resources could be considered by the municipality when reporting against facilities and housing indicators:

- Process:
    - Access municipal permits for building renovations and retrofits.
    - Calculate the proportion of renovated buildings compared to the total number of buildings.
    - Verify through surveys or consultations with local contractors.

[19] Helsinki Energy and Climate Atlas

- Sources of data:
    - Municipal planning or construction departments.
    - Building and housing associations.
    - Local construction companies.

- Stakeholders to engage with:
    - Urban planning departments.
    - Building contractors.
    - Property owners' associations.
    - Residents who undertook building renovations.

What to do when data is not readily available?

The following options could be considered as an example by the municipality:

- Option 1: Track renovation permits and survey local contractors to get estimates of renovation activities.

How cities are using information on building stock for planning needs:
The city of San Francisco (United States) has collected and digitalised the records of building permits for public access. All permits of San Francisco since 1901 are tabulated for download and kept up-dated periodically on the open data portal of the city. This dataset is a powerful resource for gathering information on the city's buildings renovation history. It can be used as a source for numerous further analyses on the building stock and planning system. In addition, the data is geographically mapped[20].

- Option 2: Use national building renovation statistics together with other relevant sources at local level (e.g., population, GDP, building stock age) to weight the data and have an estimation of the yearly renovated buildings, assuming that the municipality follows similar trends. However, since these estimates are derived and elaborated, and not directly collected from local data sources, some discrepancies are possible. In such cases, when information is available for a small sample of households/citizens, a comparison between data elaborated from the national/regional average and local data can help assess the extent of the divergence.

5.2.4 Share of households with issues such as leaks, dampness, or rot

Data collection steps

The following steps and resources could be considered by the municipality when reporting against facilities and housing indicators:

- Process:
    - Conduct a household survey targeting a representative sample of the population to identify the presence of leaks, dampness, or rot.
    - Work with building inspectors to conduct assessments of public housing or a sample of private residences to validate survey data
    - Combine survey results and inspection reports with existing housing quality data from municipal or national statistics to estimate the share of affected households.

[20] Building Permits | DataSF | City and County of San Francisco

- Sources of data:
    - National and regional housing surveys.
    - Municipal housing authorities.
    - Academic research or NGO reports.

- Stakeholders to engage with:
    - Municipal housing departments.
    - Residents' associations.
    - Health departments or NGOs focused on housing.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Conduct household surveys to assess housing conditions, potentially collaborating with local NGOs or universities.

  For example, to enhance understanding of housing conditions, particularly in relation to health, the city of Oslo (Norway) is planning to conduct a public health survey by reaching out 160 000 people by SMS and email.
  The survey took place between 4 – 15 November 2024 and was followed by a communication campaign aimed at increasing engagement in the local population to explain the benefits of answering the survey and providing a comprehensive picture of the local context.
  The survey includes a specific section on housing conditions and a Yes/No question on presence of moisture and rot in the house. It includes also other questions that can be relevant to energy poverty aspects, such as environmental factors and financial resilience.

5.2.5 Percentage of households/persons within the municipality experiencing heating discomfort or experiencing cooling discomfort

Data collection steps

The following steps and resources could be considered by the municipality when reporting against facilities and housing indicators:

- Process:
  - Survey a representative sample to identify heating and cooling discomfort, asking about the frequency, duration, and severity during different seasons.
  - Examine energy usage trends to validate survey findings and correlate with periods of reported discomfort.
  - Combine survey and energy data with health or social services information on temperature-related health issues for a comprehensive estimate.

- Sources of data:
  - Municipal and national surveys.
  - Energy providers.
  - Health or social services.

- Stakeholders to engage with:
  - Residents' associations.
  - Energy providers.
  - Local health authorities.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Deploy temperature and humidity sensors in selected households to gather detailed data on indoor conditions, providing insights into heating and cooling needs.

  For example, recent research explores IoT-based approaches for monitoring thermal comfort in households and municipalities. These systems utilise sensors to collect environmental data such as temperature, humidity, and CO_2 levels (López-Vargas & Ledezma-Espino, 2023; Udrea et al., 2023).
  IoT systems have potential applications in energy poverty detection by monitoring thermal efficiency parameters. Integration with smart home systems allows for efficient control of load devices to maintain optimal indoor comfort levels.

- Option 2: Use phone or online surveys to collect information from households about their experiences with heating and cooling discomfort, making data collection easier and quicker.

  For example, researchers from the University of Navarra carried out specific surveys to better understand the level of indoor thermal comfort and its causes and consequences during heatwaves in Pamplona (Spain) (Gamero-Salinas et al., 2024). The methodology used with results were published in 2024.

The surveys were conducted within the project CLIMATEREADY[21] during the summers of 2021 and 2022 and involved two types of campaigns: the summer survey and the heatwave survey.
The summer survey campaign collected comprehensive data on residents' thermal comfort, building characteristics, and personal demographics through online questionnaires shared on social media.
The heatwave survey campaign was more specific, conducted only during heatwave periods, and included additional questions about strategies used to cope with heat and the indoor environment, such as thermostat temperatures and health-related issues.
Surveys included six questions that covered thermal sensation, thermal satisfaction, and thermal preference during the day and night.

Other examples of campaigns and studies on indoor thermal comfort or indoor overheating using surveys or mixed-methods can be also found in Australia (Zander et al., 2023), New Jersey (Tsoulou et al., 2023) and England.

5.2.6 Households/persons connected to the electricity grid or to the gas grid / total number of households/persons

Data collection steps

The following steps and resources could be considered by the municipality when reporting against facilities and housing indicators:

- Process:
  - Obtain data from local electricity and gas utilities, focusing on the number of connected households and non-connected households within the municipality.
  - Perform spot checks in neighbourhoods with suspected lower connectivity to validate the utility records.
  - Integrate utility records and field data to calculate the connection ratio for electricity and gas, ensuring coverage across different areas.

- Sources of data:
  - Utility company records.
  - Municipal planning documents.
  - National energy databases.
  - Distribution systems operator database.

- Stakeholders to engage with:
  - Distribution system operator.
  - Utility companies.
  - Local government planning departments.
  - Community organizations for on the ground data verification.

What to do when data is not readily available?

[21] https://experience.arcgis.com/experience/a85fb262378b49dc87381261a2e53c91/page/ClimateReady/

The following options could be considered as an example by the local authority:

- Option1: Employ geographic information system (GIS) mapping combined with remote sensing to assess infrastructure coverage, allowing for a comprehensive view of electricity and gas network reach.

  For example, municipalities can exchange with the distribution system operators (DSO) and cooperate with them. This is exchange can fall within larger cooperation in which the municipality and the DSO collaborate to prevent disruption of city activities and ensure that the status and needs of the grid are considered in urban planning and local decision-making.

- Option 2: Use community-based surveys or local meetings to identify areas with grid access issues. This approach relies on community knowledge to flag gaps in service without extensive technical efforts.

5.3 Data collection pathways for mobility indicators

5.3.1 Population not having access to essential services within one hour

Data collection steps

Essential services may refer in this context to public or private providers of goods or services to citizens, i.e. food stores, education and health facilities, cultural and sports facilities. Spending one hour or more to reach these services is an indicator of transport poverty and transport-based social exclusion.

GIS is a powerful tool to assess identify car-dependent and commuters' areas, as well as the location of services. Through GIS, the analysis of services' accessibility, public transport, the presence of walking and cycling infrastructure can be combined. GIS data can be collected from various sources, including OpenStreetMap, microdata from the national institute of statistics, road network database. Occasional data gaps can be complemented by surveys and site visits.

The following steps and resources could be considered by the municipality when reporting against mobility indicators:

- Process:
    - Map essential services (e.g., healthcare, schools, supermarkets) using GIS tools.
    - Combine the information on essential service with the population/household distribution.
    - Analyse travel time data from various transport modes (walking, cycling, public transit). Specific GIS spatial analysis as well as dedicated web applications can be used.
    - Validate and supplement findings with community surveys to capture experiences.

- Sources of data:
    - Census data.
    - Municipal transportation departments.
    - GIS databases (e.g., OpenStreetMap).
    - Mobility reports from regional authorities.

- Stakeholders to engage with:
    - Public transportation authorities.
    - Community groups.
    - Urban mobility researchers.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

Option 1: Mapping the time required to reach services using GIS tools and detailed surveys among citizens and stakeholders for different transport modes.

Option 2: Open tools able to create isochrones maps per mode of transport are available online. Isochrone maps are powerful tools that can support the understanding of the level of accessibility of services, areas, buildings. These can be used to roughly estimate the time needed to reach essential services by overlapping the maps of the points of interest.

5.3.2 People living more than one km from the nearest public transport station

Data collection steps

This indicator provides one measure of accessibility of people to the public transport service. It is an indicator also of the capillarity of the public transport network. Diverse recommendations exist for acceptable walking distances to a public transport stop. One kilometre is already a threshold above which the accessibility can be considered low. Disadvantages related to low accessibility include reduced opportunities, social isolation, limited access to amenities and jobs. The spatial information on households' distance further enables the evaluation of the accessibility of transit services, identify areas with limited transit access, and inform transportation planning and policy decisions.

The following steps and resources could be considered by the municipality when reporting against mobility indicators:

- Process:
    - Information on the location of the transit stops and schedules.
    - Household distribution.
    - Calculate distances from residential areas to the nearest station.
    - Map and classify areas according to the calculated distance.
    - Conduct household surveys to validate GIS-based estimations.

- Sources of data:
    - Public transport authority datasets.
    - Census data.
    - Municipal GIS data.
    - Urban planning departments.

- Stakeholders to engage with:
    - Local transport agencies.
    - City planners.
    - Community organizations.
    - Residents.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Conduct household travel and public transportation user surveys to collect specific information, including socio-economic attributes, trip purposes, travel modes, residential and workplace locations. Use online mapping tools to measure approximate distances between residential areas and public transport stops.

- Option 2: Use results from EUROSTAT or national statistics and estimate the local conditions by downscaling these statistics to the local population.

  For example, the EU-SILC, under the "Housing conditions" module, made available data on the "Distribution of population by level of difficulty in accessing public transport, income quintile and degree of urbanisation" for EU countries and Iceland, Norway, Switzerland and UK for 2012 and 2014[22].

[22] https://ec.europa.eu/eurostat/web/income-and-living-conditions/database

5.4 Data collection pathways for socio-economic indicators

5.4.1 Percentage of persons/households spending up to X% of income on energy services

Data collection steps

The following steps and resources could be considered by the municipality when reporting against f socio-economic indicators:

- Process:
  - Gather household income and energy expenditure data from national or municipal surveys.
  - Calculate the share of income spent on energy per household.
  - Analyse the results to determine how many households exceed the energy affordability threshold.
- Sources of data:
  - National statistics offices (e.g., Eurostat).
  - Household expenditure surveys.
  - Local utility companies.
- Stakeholders to engage with:
  - Social services departments.
  - Energy regulators.
  - Consumer advocacy groups.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Collect data through households' income and expenditure surveys, potentially conducted with local social services.

For example, the Bristol Energy Network have supported the involvement of fuel poor households in innovation projects, such as REPLICATE (see below) as well as developing new innovative projects such as the "cold homes energy efficiency survey experts" (CHEESE) project [23] [24]. The CHEESE Project is a pilot project in Bristol (UK), developing a city-wide scheme that uses thermal imaging to highlight areas of heat loss in people's homes. It has the triple aim of lowering energy consumption, saving householders' money and reducing the carbon footprint of Bristol homes [25]. Similar approaches are used also in other countries, such as Canada [26].

- Option 2: Explore the availability of tools or proxies and engage with research institutions to assess the potential and interest for their development.

[23] https://democracy.bristol.gov.uk/documents/s71925/10b%2520-%2520Bristol%2520Fuel%2520Poverty%2520Action%2520Plan.pdf

[24] https://www.bristol.gov.uk/council/statistics-census-information/quality-of-life-in-bristol

[25] https://bristolenergynetwork.org/wp-content/uploads/2017/12/CHEESE-Project-case-study.pdf

[26] https://www150.statcan.gc.ca/n1/pub/46-28-0001/2024001/article/00001-eng.htm

For example, the low-income energy affordability data (LEAD) tool developed by the U.S. Department of Energy, allows communities to analyse energy burdens across different income levels. It utilises data from households' income and expenditure surveys to assess how energy costs impact low-income households. The data presented in the tool is based on five-year running averages. For this reason, it can be used as an approximation of the local situation but cannot be used as a detailed project management tool or considered to describe year-on-year changes[27].

5.4.2 Vulnerable households or persons / total households or persons

Data collection steps

The following steps and resources could be considered by the municipality when reporting against socio-economic indicators:

- Process:
    - Gather household socio-economic data from national or municipal surveys.
    - Identify households that are part of vulnerable groups (such as: below income poverty line, elderly, children, people with disabilities).
    - Analyse the results to determine how many households have vulnerable people.

- Sources of data:
    - National statistics offices (e.g., Eurostat).
    - Household surveys.

- Stakeholders to engage with:
    - Social services departments.
    - Energy regulators.
    - Consumer advocacy groups.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Collect data through household income and expenditure surveys, potentially conducted with local social services.

- Option 2: Use national or regional data on energy expenditure and income levels to estimate and approximate the situation locally using normalisation methods. However, this approach would not be highly reliable but can be used for forming an initial understanding of the situation to be finetuned and confirmed once data at the local level becomes available. In addition, when information is available for a small sample of households/residents, a comparison between data elaborated from the national/regional average and local data can help assess the extent of the divergence.

[27] https://www.energy.gov/sites/default/files/2024-07/lead-tool-factsheet_072624.pdf

5.4.3 Arrears on utility bills

Data collection steps

The following steps and resources could be considered by the municipality when reporting against socio-economic indicators:

- Process:
    - Obtain data on overdue utility payments from local utility companies.
    - Identify patterns and trends by income group or geographic area.
    - Verify findings through interviews with social service providers.
- Sources of data:
    - Local utility companies.
    - National statistics on energy poverty.
    - Municipal social services.
- Stakeholders to engage with:
    - Utility companies.
    - Social welfare agencies.
    - NGOs focused on poverty alleviation.

What to do when data is not readily available?

The following option could be considered as an example by the local authority:

- Partner with utility companies to access anonymised billing data on arrears and payment delays.

5.4.4 Inability to keep home adequately warm or adequately cool

Data collection steps

The indicator refers to the percentage of people in the total population who are in the state of enforced inability to keep home adequately warm or cool. This may derive from a combination of factors, hence, several data sources and methods should be processed to gain insightful and accurate information.

The following steps and resources could be considered by the municipality when reporting against socio-economic indicators:

- Process:
    - Conduct a survey mainly targeting lower-income households and vulnerable groups to understand if financial constraints or building-related reasons prevent maintaining comfortable indoor temperatures. Include questions on the indication of the causes and about income allocation towards energy bills.
    - Review data on households with utility payment arrears or those facing disconnections, as they may be at higher risk of thermal discomfort due to economic hardship.
    - Examine records from social services on households receiving energy subsidies or financial aid for heating and cooling needs, as this can indicate economic barriers to adequate indoor temperatures.

   - Examine records from building departments to check buildings recently renovated, in the process of being renewed or in need of renovation.

- Sources of data:
   - Socio-economic household surveys.
   - Utility company data on arrears or disconnections.
   - Social welfare or assistance records.
   - Non-profit organizations' reports.
   - Building permits records.

- Stakeholders to engage with:
   - Social welfare departments.
   - Non-profit and charitable organizations.
   - Economic researchers or academic institutions operating at local level.
   - Residents.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Access and downscale EUROSTAT or national statistics to estimate the local conditions. The EU-SILC, under "Economic strain" module[28], made available data on the "Inability to keep home adequately warm by NUTS region" at NUTS2 level for EU countries and many others from 2021.

  The EPAH provides levels of disaggregation for this indicator, available at National indicators | Energy Poverty Advisory Hub[29]. Information is available for different categories of data, such as type of dwelling, type of household, ownership, income quintiles and deciles. This disaggregation provides insights supporting analysis to identify most affected and vulnerable population groups.

- Option 2: Implement comprehensive, income-focused surveys to gather data on energy expenditure, affordability, and households' financial struggles related to thermal comfort.

[28] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU_statistics_on_income_and_living_conditions_(EU-SILC)_methodology_-_economic_strain

[29] https://energy-poverty.ec.europa.eu/epah-indicators

5.4.5 High share of energy expenditure in income (2M) and Low absolute energy expenditure (M/2)

Data collection steps

The following steps and resources could be considered by the municipality when reporting against socio-economic indicators:

- Process:
  - Gather data from household budget surveys or utility records on annual income and energy expenditures for households in the municipality.
  - Determine the median share of energy expenditure relative to income at the national level, which serves as the benchmark.
  - Calculate the proportion of households whose energy expenditure share is more than twice the national median, classifying them as high energy burden cases.

- Sources of data:
  - Household budget surveys.
  - National statistical offices.
  - Consumer financial surveys.

- Stakeholders to engage with:
  - National statistical agencies.
  - Social services and welfare agencies.
  - Financial advocacy groups.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

Option 1: Conduct comprehensive surveys specifically designed to gather data on income and energy expenditures from a representative sample, including different socio-economic groups.

For example, the municipality of Barcelona (Spain) through the project "Indicadors municipals de pobresa energètica a la ciutat de Barcelona" focused on compiling and analysing local data and indicators to estimate energy poverty at the city level in Barcelona. While energy poverty data is typically available only at national or regional levels, municipalities in Barcelona leveraged a unique wealth of information from state surveys, local projects, and municipal services, such as social services and energy advisory points, providing an unparalleled basis for city-scale assessment[30] .

Another example comes from researchers of the Universidad Politécnica de Madrid that collected information within the city of Madrid (Spain) regarding the 2M indicator to produce analysis and recommendations on the evaluation and quantification of energy poverty in Madrid (Sánchez et al., 2020).

[30] https://energy-poverty.ec.europa.eu/discover-community/epah-atlas/energy-poverty-indicators-municipal-scale-barcelona

Option 2: If direct data is not available, use energy burden statistics from regions with similar socio-economic profiles to estimate the share of households likely exceeding the 2M threshold, acknowledging the level of approximation.

5.5 Data collection pathways for policy and regulatory indicators

5.5.1 Existence of energy poverty strategy

Data collection steps

The following steps and resources could be considered by the municipality when reporting against policy and regulatory indicators:

- Process:
  - Check local government policy documents, strategic plans, or municipal energy action plans to determine if an energy poverty strategy is explicitly mentioned.
  - Consult local councils, policy committees, or relevant municipal departments to verify the existence and content of the energy poverty strategy.
  - Determine if the municipality's energy poverty strategy aligns with or is derived from higher-level national or regional strategies.

- Sources of data:
  - Municipal strategic and energy plans.
  - Local government meeting minutes.
  - National and regional energy plans.

- Stakeholders to engage with:
  - Municipal policy makers.
  - Energy and environmental departments.
  - Regional or national policy experts.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: If no strategy exists, facilitate a participatory process to create one, involving stakeholders from government, civil society, and industry. Use international guidelines to inform best practices.

- Option 2: If developing a full strategy is not feasible, pass a policy resolution recognizing energy poverty as a priority. This signals commitment and can be used to guide smaller actions.

5.5.2 Existing rent regulation

Data collection steps

The following steps and resources could be considered by the municipality when reporting against policy and regulatory indicators:

- Process:
  - Check municipal and regional legislation to see if there are provisions for rent control, caps on rent increases, or tenant protection laws.

    - Engage organizations that assist renters to confirm the presence and enforcement of rent regulations.
    - Determine if the local regulations align with or differ from national rent control policies.
- Sources of data:
    - Municipal housing regulations.
    - Regional or national housing policy databases.
- Stakeholders to engage with:
    - Local housing authorities.
    - Tenant advocacy groups.
    - Real estate market analysts.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

- Option 1: Perform a comprehensive review of local, regional, and national regulations on rent.

- Option 2: Conduct quick surveys of tenants to gauge the extent of rent protections and perceived adherence to rent regulations.

5.6 Data collection pathways for participation and awareness raising indicators

5.6.1 i) Awareness raising campaigns targeting vulnerable households and ii) Engagement and cooperation with local stakeholders on energy poverty

Data collection steps

The following steps and resources could be considered by the municipality when reporting against participation and awareness raising indicators:

- Process:
  - Review municipal records, community reports, and social services documents to list existing awareness campaigns and stakeholder engagement efforts on energy poverty.
  - Conduct surveys or interviews to assess the reach and impact of campaigns and engagement activities, and to identify gaps in participation.
  - Use survey results and meeting records to evaluate the effectiveness of outreach efforts and the extent of stakeholder collaboration on energy poverty issues.
- Sources of data:
  - Municipal communication records.
  - Reports from community and social services.
  - Local media coverage.
- Stakeholders to engage with:
  - Community-based organizations.
  - Local NGOs and charities.
  - Educational institutions.
  - Energy providers.

What to do when data is not readily available?

The following options could be considered as an example by the local authority:

Option 1: Establish a system to track all awareness campaigns and stakeholder engagement activities systematically, to do event tracking, survey collection, and impact analysis.

Option 2: Conduct small-scale focus groups with local stakeholders and vulnerable households to gauge the perceived reach and impact of campaigns carried out in the past.

6 Conclusions

This document serves as an essential guide to carry out an energy poverty assessment at the local level. It offers a structured approach for municipalities to identify, understand, and monitor the multiple aspects of energy poverty, providing a solid foundation for informed decision-making and impactful action.

The guidance emphasises the importance of adaptability in addressing data gaps, offering practical strategies through the data collection pathways, suggesting options and approaches to be used in the absence of readily available data.

The document underscores the necessity of fostering collaboration among stakeholders, including local NGOs, educational institutions, and energy providers, to ensure inclusive and sustainable energy transitions. By embedding energy poverty alleviation into broader climate and social policies, municipalities can address systemic challenges while promoting equity and resilience in vulnerable communities.

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List of abbreviations and definitions

Abbreviations	Definitions
2M	High share of energy expenditure in income
CDD	Cooling degree days
CoM	Covenant of Mayors for Climate and Energy
C3S	Copernicus Climate Change Service
CRF	Common reporting framework
DBSM	Digital building stock model
DG ENER	Directorate-General for Energy
DG CLIMA	Directorate-General for Climate Action
DSO	Distribution system operators
EC	European Commission
ECA&D	European Climate Assessment & Dataset
EDO	European Drought Observatory
EEA	European Environment Agency
EED	Energy Efficiency Directive
EPAH	Energy Poverty Advisory Hub
EPC	Energy performance certificate
ECMWF	European Centre for Medium-Range Weather Forecasts
EU SILC	European Union Statistics on Income and Living Conditions
GCoM	Global Covenant of Mayors for Climate and Energy
GIS	Geographic information systems
HDD	Heating degree days

Abbreviations	Definitions
HEKA	Helsinki Housing Company
JRC	Joint Research Centre
LCZ	Local climate zones
LEAD	Low-income energy affordability data
M/2	Low absolute energy expenditure
NGO	Non-governmental organisation
NUTS	Nomenclature of territorial units for statistics
SECAPs	Sustainable energy and climate action plans
UHVI	Urban heat vulnerability index

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Annexes

Annex 1. The EU Energy Poverty Advisory Hub

The Energy Poverty Advisory Hub (EPAH) is the leading EU initiative run by the European Commission at the request of the European Parliament. It is a collaborative network of stakeholders aiming to eradicate Energy Poverty and accelerate the just energy transition of European municipalities.

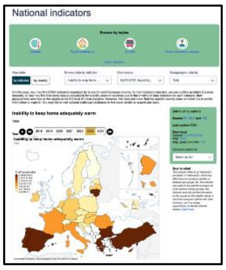
The guidance provided in this guidebook How to Develop an Energy Poverty Assessment focuses on energy poverty while also considering the Covenant's mitigation and adaptation pillars, offering a holistic approach for Covenant signatories. In contrast, the documentation produced by EPAH targets a broader audience beyond Covenant signatories and focuses solely on energy poverty.

This Annex provides a selection of materials and guidance developed by EPAH. The guidance in this guidebook How to Develop an Energy Poverty Assessment and EPAH's resources listed below complement each other.

1. **EPAH's tools and reports**

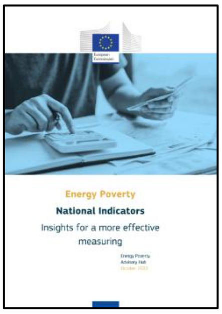
EPAH provides a dashboard and a series of reports on energy poverty indicators and measurements, providing useful information to support governments and practitioners in their efforts to conduct an energy poverty diagnosis in their territories and populations. These materials consist of:

- The ***"National EPAH Indicator Dashboard"*** presents EPAH national indicators based on publicly available EU-wide datasets organised by topic or country for each European Union country.
- The ***"****Bringing energy poverty research into local practice - Exploring subnational scale analyses****"*** *report* conducts a scientific literature review of studies that delve into energy poverty assessment at subnational spatial scales.
- The ***"Energy Poverty Advisory Hub National Indicators: Insights for a More Effective*** *Measuring****"*** *report* conducts an extensive review and in-depth analysis of the existing national energy poverty indicators.
- The ***"Energy Poverty Advisory Hub*** *National Indicators: Uncovering New Possibilities for Expanded Knowledge****"*** *report* revises and updates the existing national energy poverty indicators.



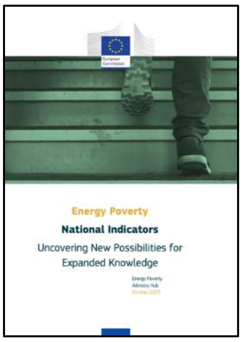
The National Indicator Dashboard is an online digital platform where the EPAH's energy poverty indicators are presented in map and graph form, organised by topics for each European Union country. This indicator collection is comprised of 28 indicators. It uses publicly available regularly updated EU-wide datasets, outlining their geographical coverage, timeline, unit, data source, and last update, enabling comparison between member states. It also briefly analyses their application uses, limitations, and strengths.

The **"**<u>Bringing energy poverty research into local practice - Exploring sub-national scale analyses</u>***"*** report conducts a thorough scientific literature review of studies that delve into energy poverty assessment and identify and target the energy-poor population at subnational spatial scales (smaller than national). This report aims to investigate, identify, and analyse the variety of data sources, datasets, and methods used in the literature for assessing energy poverty at greater spatial resolution for specific contexts, territories, and populations. Ultimately, the goal is to collect helpful information and knowledge and channel it in the direction of local governments and organisations to inform their local practice and initiatives.



The "<u>Energy Poverty Advisory Hub National Indicators: Insights for a More Effective Measuring</u>" report conducts an extensive review and in-depth analysis of the existing energy poverty indicators derived from the past indicators database, supported by state-of-art scientific literature and energy poverty expertise. It reflects on the past, current, and future of data and indicator availability, conducting an update when new data is available of the existing indicators, identifying advantages and shortcomings, mismatches, misleading interpretations, and inconsistencies. It aims to aid member states in understanding and diagnosing energy poverty levels and develop strategies and policies to plan and implement mitigation measures.

The "*<u>Energy Poverty Advisory Hub National Indicators: Uncovering New Possibilities for Expanded Knowledge</u>***"*** report focuses on the latest updates and enhancements to EPAH energy poverty national indicators and dashboard in 2023. The revision aims to further develop the knowledge and tools provided by EPAH to contribute to improving energy poverty measurements across the EU. It reorganises and updates existing indicators, removes redundant ones, and incorporates new (sub)topics and indicators. The update aims to deepen and broaden EP measurement by integrating more EP-related dimensions such as health, energy consumption and transportation to equip policymakers, researchers, and practitioners with a toolkit that enables more comprehensive approaches.



2. **EPAH's Handbooks**

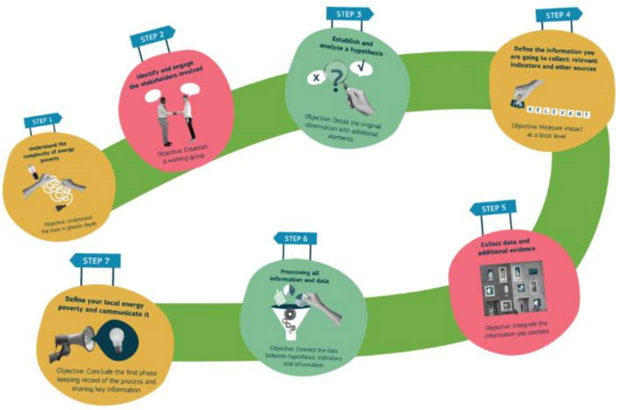
EPAH provides a series of practical guidebooks for local governments and practitioners, which ensure that the social dimensions of energy transition are addressed efficiently. This series consists of:

- The ***"Introduction to the EPAH Handbooks: A Guide to Understanding and Addressing Energy Poverty"*** which establishes the common background to all three handbooks.
- The ***"EPAH Handbook 1: A Guide to Energy Poverty Diagnosis"*** which focuses on the practical assessment of energy poverty at the local level.
- The ***"EPAH Handbook 2: A Guide to Planning Energy Poverty Mitigation Actions"*** which provides information on how to prepare and integrate an energy poverty mitigation plan within the *Local Social Climate Plan.*
- The ***"EPAH Handbook 3: A Guide to Implementing Energy Poverty Mitigation Actions"*** which provides information on the execution of an effective energy poverty project.

The guidelines are designed to follow the EPAH methodology structured in three phases: diagnosis, planning and implementation. EPAH strongly advice the local governments to follow the guidelines as they are designed. It is of primary importance to take adequate time to understand the challenges and to design a response. A robust diagnosis will allow to answer the most relevant questions when designing effective solutions. Consequently a strong planning will facilitate the implementation phase and increase the likelyhood of delivering a concrete impact.

The guidelines are designed to be adaptable to different situations. The basic idea is that it is useful as a starting point in acting against energy poverty, whether you have prior knowledge or not. Whether you have many resources or few resources. Keep in mind that the proposed methodology is a circular model, such that it is possible to start with limited resources and perform a first step which may be expanded later in the process.

The Diagnosis Handbook focus on assessing energy poverty. It outlines key steps for conducting a Local Energy Poverty Diagnosis, helping identify affected households, underlying causes, and intervention strategies. The handbook provides a flexible, step-by-step approach adaptable to different local contexts, regardless of prior expertise or available resources. By establishing a strong evidence base, it supports informed decision-making, stakeholder engagement, and policy development. The key step proposed are:



Step 1: Understand the complexity of energy poverty

Step 2: Identify and engage the Stakeholders involved

Step 3: Establish and analyse a hypothesis

Step 4: Define the information you are going to collect: relevant indicators and other sources

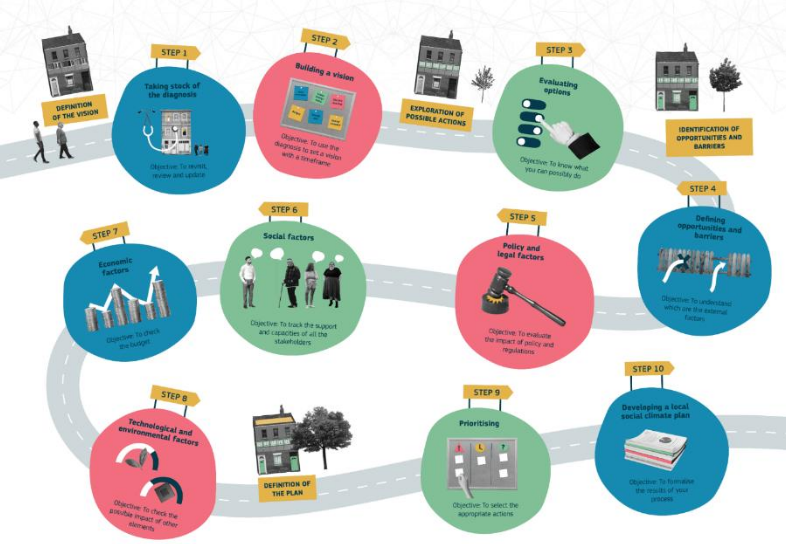
Step 5: Collect data and additional evidence

Step 6: Processing all information and data

Step 7: Define your local energy poverty and communicate it

The Planning Handbook guides municipalities in translating energy poverty diagnosis into concrete, actionable plans. This phase focuses on prioritizing interventions that are realistic, impactful, and aligned with local climate strategies. It emphasises the importance of setting clear goals, engaging vulnerable consumers, and ensuring feasibility. The handbook supports municipalities in integrating energy poverty measures into broader climate plans, such as SECAPs or Local Social Climate Plans. Effective planning increases the success of mitigation actions and strengthens connections to national and EU policies.

The second planning handbook presents different practical steps to identify the most feasible and impactful actions to prioritise at the local level.



Step 1: Taking stock of the diagnosis

Step 2: Building a vision

Step 3: Evaluating options

Step 4: Defining barriers and opportunities

Step 5: Political and legal factors

Step 6: Social factors

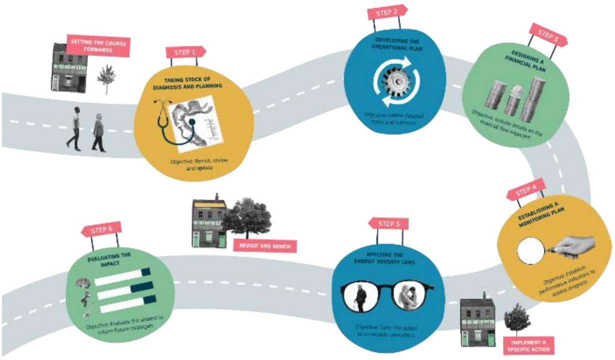
Step 7: Economic factor

Step 8: Technological and environmental factors

Step 9: Prioritising

Step 10: Developing a local social climate plan

The third Implementation Handbook is the final step in tackling energy poverty, turning plans into concrete actions. It guides municipalities in executing approved and financed measures, ensuring a just and fair energy transition. The handbook provides a structured 6-step approach to help municipalities implement, monitor, and refine their energy poverty mitigation strategies. While challenges vary by region, this resource ensures tailored, effective solutions. By building on prior knowledge and tested approaches, municipalities can drive meaningful change and create a resilient, socially inclusive, and sustainable future for all. In this case six steps are proposed:



Step 1: Taking stock of diagnosis and

Planning

Step 2: Developing the operational plan

Step 3: Designing a financial plan

Step 4: Establishing a monitoring plan

Step 5: applying the energy poverty lens: Implement a specific action

Awareness campaigns, behavioural change, one-stop shops, energy communities, home renovation and energy efficiency improvement, incentive regulations and financial measures, other types of actions such as artificial intelligence

Step 6: Evaluating the impact: Revisit and renew the cycle

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